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The average height of 18- and 19-year-old conscripts (N=458,322) in Switzerland from 1992 to 2009, and the secular height trend since 1878

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Summary

QUESTION UNDER STUDY: We determine the causes of secular changes in the average height of the male Swiss population for the first time by analysing an unbiased, individually measured, highly representative height-data sample of 18- and 19-year-old Swiss conscripts (N = 458,322) at the national level spanning the years 1992 to 2009. Furthermore, we add historical context based on earlier data from the same source.

RESULTS: In 2009, the average height of regularly 19-year-old Swiss conscripts was 178.2 cm. Percentiles were P5 = 168 cm, P10 = 170 cm, P25 = 174 cm, P50 = 178 cm, P75 = 182 cm, P90 = 187 cm, and P95 = 189 cm. Over the course of the 130 years between 1878–79 and 2009 the average height of 19-year-old conscripts increased by a total of 14.9 cm. The distribution shifted upwards. In 1878–79, 5.48% of conscripts were 175 cm tall or taller, but only 0.89% were 180 cm tall or taller. In 2008–09, 71.13% of the conscripts were 175 cm tall or taller, and 41.69% 180 cm tall or taller. In recent decades, this trend has slowed markedly.

CONCLUSIONS: While the increase in average height among Swiss conscripts (representative 90% of the male Swiss population) since the 19th century is usually attributed to improvements in living conditions, all of the factors contributing to the recent slowdown have yet to be identified.

Key words: height; male; secular trend; Switzerland; growth standard; conscription

Introduction

From the third quarter of the 19th century until the last decade of the 20th century, average human height increased at a steep and steady rate throughout the Western world, including Europe [1–6]. This (positive) secular trend for av-

erage body height has been observed since the beginning of the 20th century [7; 8]. Along with a faster rate of physical development and an earlier onset of menarche, this increase in average height is part of the secular acceleration phenomenon [9–11; 3].

Average height trends at the national level have been well documented, based primarily on conscription and health survey data [e.g. 12]. A huge body of data on individual conscripts (men from 18 to 21 years of age) are available for analysis. On the other hand, research on secular height changes in general is hindered by three major difficulties regarding consistency. Firstly, international comparability is limited by differences among military draft systems and policies, including the age of conscription and minimum height requirements [13–14]. Secondly, since the 1990s the height data recorded in national and international health surveys as well as household panels have been of the self-reported variety, leading to an overestimation of mean height [15–16]. Thirdly, the earliest data from health surveys date from the 1950s (analysed by year of birth).

Economic historians have studied the secular height trends of Switzerland's neighbours: France [17–21], Germany [22–24], Austria [25–26], and Italy [4], and in both Austria [27–28] and Germany [29–30], medical, auxological and anthropological studies of height trends have provided insights into secular height trends by drawing on national conscript data.

Both long term and recent height trends at the multinational level have been studied. Deaton [31] used health survey and household panel data to track both male and female mean height trends worldwide since the 1950s, whereas Garcia and Quintana-Domecque [32] used the same category of sources but limited the scope of their study to Europe. In their study of European conscripts during the period 1960–90 Schmidt et al. [33] concluded that since the 1980s the growth trend in the Netherlands and Scandinavia slowed to a stable mean height of 179–181 cm, whereas there was no such slowdown among southern European

conscripts. Larnkjær et al. [34], in a study spanning the following 15 years, reported that average heights reached a plateau in northern Europe and Italy, whereas they continued on their upward trend in Spain and Portugal. Both Susanne et al. [35] and Danubio [36] reached the same conclusion. Hatton and Bray [12], drawing on both conscription and health survey data for the birth cohorts 1856–1980, found that over the entire 124 year period the average height of males of conscription age throughout Western Europe increased at an average rate of 1 cm per decade, and nearly doubled during the years between the First and Second World Wars. Several studies describe a slowdown in the US height trend that has inversed the gap between the US and Europe in the 20th century [37, 38] and catch-up growth on the part of conscripts from eastern Germany after reunification [24, 39, 40].

Precise information on adult male height in present day Switzerland, not to mention its recent and long term secular trends, is scanty, as the preceding summary of height trends in Europe, from which Switzerland is glaringly absent, attests. According to Swiss longitudinal growth standards (based on measurements of individuals born in the 1950s), a Swiss male attains his maximal height at the age of 19 [41–42]. (In Switzerland, new growth curves have recently been implemented. In case of length and height, the authors adopt the reliable curves from the WHO Multicenter Growth Reference Study (MGRS) and from National Center for Health Statistics (NCHS), see Braegger C, Jenni O, Konrad D, Molinari L. *Neue Wachstumskurven für die Schweiz*. *Paediatrica*. 2011;22(1):9–11.)

If self-reported height data in the 2007 Swiss Health Survey are to be taken at face value, the average height of the Swiss resident male population between the ages of 15 and 24 was 177.9 cm [43]. Rühli et al. [44] reported the simple average height of conscripts in the 2005 census (178.1 cm, $N = 28,512$) and performed both punctual and cross-sectional calculations for the height trend since the late 19th century. The most recent medical study concerned with the secular height trend of Swiss conscripts in Switzerland was published by Ziegler in 1966 [45] and the most recent release, by the Federal Statistical Office BFS and the Swiss Army, of aggregate results from medical examinations of conscripts, including average height, dates from 1989 [46].

Recent anthropometric studies have drawn on Swiss conscription data. Rühli et al. [44] analysed 2005 height, weight, and BMI figures, and later in the same year [47] they examined total cholesterol figures that were based on 2005 mandatory blood samples. Staub et al. [48] drew on individual conscript data to chart the changes in conscripts' BMI distribution since the late 19th century, whereas Schoch et al. [49] drew on individual height data from Basel, Zürich, and the canton of Bern to trace the evolution of the biological standard of living over 75 years, 1875–1950. A research project, funded by the Swiss National Science Foundation at the University of Bern, culminated in a PhD thesis that featured height data derived not only from military records but also from prison and passport files [8].

The aim of this study is twofold. Firstly, to provide the first year by year analysis of individual Swiss conscript

height data for the period 1992–2009 ($N = 458,322$), and secondly, by calculating averages and percentiles on the basis of a recent population study, to establish precise estimates of the average growth rate of Swiss men of 18 to 19 years of age. Our extensive database, comprising all extant records of national mean height values since 1878, permits us to add Switzerland, at long last, to the group of countries featured in international studies of secular height trends.

Data and methods

Individual height data in digital form for the conscription years 1992–2009 was provided by the Swiss Army (Logistikbasis der Armee, LBA San). As the data included both the exact date of birth of each conscript and the date of his medical examination, we were able to construct two groups defined by biological age (down to the month) for the period 1992–2009: 18 years 0 months to 18 years 12 months ($N = 219,258$) and 19 years 0 months to 19 years 12 months of age ($N = 239,064$). The sample thus comprises 458,322 individuals. For the conscription year 2009, we also computed height values for 20- and 21-year-old conscripts. Since earlier data include conscripts of 19 years of age or even younger, we included an age group of conscripts 18 and 19 years of age in addition. We excluded the few individuals whose height deviated more than ± 5 standard deviations (SD) from average (including those for whom the data were either incomplete or evidently in error: e.g., a height of 90 cm combined with a weight of 175 kg). We analysed both height averages and percentiles.

For the almost 40 conscription years 1952–1987, there exist only quinquennial and officially published average height values [46]. Prior to 1950, the individual data, in the form of medical examination control books, were stored in cantonal archives. As these individual data are so voluminous as to be impractical as a research source to compute an average height at national level, we had to rely on national average height numbers published by the Swiss Army.

Similar height averages were published by the Ministry of the Interior (Eidgenössisches Departement des Inneren, EDI) in the years 1879 (for the conscription years 1878 and 1879) [50], 1884–1891 [51] and 1914 (for the conscription years from 1908 to 1910) [52], or, by the official daily newspaper of the Social Democratic party, *Volksrecht* (10 September 1910, p. 2), Pittard and Dellenbach [53] and Schlaginhaufen [54–55]. Most published historical averages are those of 19-year-old conscripts. Exceptions are height values for the war years 1944 and 1945, which are based on those of 18-year-old conscripts, as the minimum conscription age had temporarily been dropped by a year due to the recruitment of a twofold census in 1939 in order to consolidate the armed forces at the beginning of the Second World War, and those for the years 1982 and 1987, which include conscripts of both 18 and 19 years of age.

All mean height values are based on measurements made in the course of the medical examination that is part of the conscription process, of all those conscripted (including those later exempted from military service), with the exception of those conscripted in 1977, for which we have a reliable random sample provided by the Swiss Army. Anthropological data for the years 1928–1932 drawn from

Schlaginhaufen [54–55] complement the standard conscription data in that each annual average is derived from a different army division.

Height data from Swiss conscription records is very reliable for several reasons. Since 1875 the Swiss Army has been based on a system of involuntary conscription. The medical examination that is part of the conscription process includes the recording of standardised and unmodified anthropometric data. In 1874, in conjunction with a reorganisation of the military system, it was specified that the conscription age of all male citizens was henceforth the 19th anniversary of their birth.

The records of the medical examination procedure (a procedure that remains basically unchanged to this day) included the height, measured under medical supervision [8, 56], of every conscript, including those who subsequently received either a deferral or an exemption. Conscription now takes place throughout the country at dedicated conscription centres, where the procedure is organised and conducted according to identical qualitative standards for technical equipment as defined by Swiss Armed Forces regulations that have, of course, evolved since they were established in 1875. It has been demonstrated that during the late 19th century the conscript subpopulation and the 19-year-old male resident census subpopulation were one and the same [48–49]. Moreover, Swiss conscription data remain a useful database for population studies; for instance, the 2005 Armed Forces census represented 80% of all 19-year-old male Swiss citizens [44].

Results

Individual data 1992–2009

In 2009, the average height of Swiss conscripts at 19 years of age (birth year 1990, mean age 19 years and 6 months) on the day of conscription was 178.2 cm (N = 12 447), and the standard deviation (SD) was 6.52 cm. The percentiles were as follows: P5 = 168 cm, P10 = 170 cm, P25 = 174 cm, P50 = 178 cm, P75 = 182 cm, P90 = 187 cm, and P95 = 189 cm (table 1). Heights for the conscription years 2008 and 2009 (N = 28332) ranged from a minimum of 147 cm to a maximum of 208 cm (fig. 1).

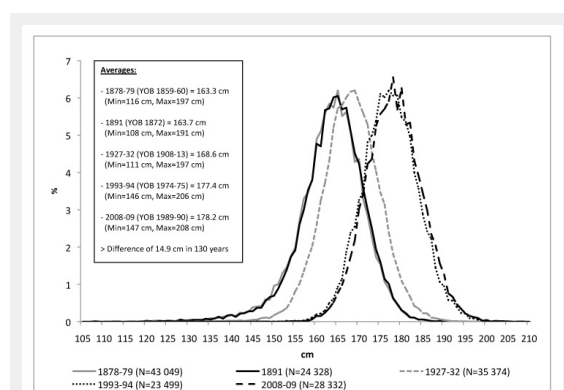


Figure 1

Shifting of the height distribution of 19-year-old Swiss conscripts from 1878–79 to 2008–09 (complete conscription years).

The average height of conscripts at 18 years of age (birth year 1991, mean age 18 years and 8 months) was 178.3 cm (N = 6309), and the SD was 6.39 cm (tables 1 and 2). In 2004, new recruitment regulations took effect, one of which provided for the option of conscription – that is voluntary early conscription – at the age of 18. These younger conscripts were on average 0.1 to 0.2 cm taller than those a year older (table 1). In 2009 the height percentiles were nearly identical, the exception being P75 = 183 and P75 = 182 cm for the younger and older groups, respectively (table 1).

In 2009 the average height of conscripts at 20 years of age – that is, whose conscription had been delayed by one year – was, the same as those who had been conscripted that year at the age of 19, 178.2 cm (N = 6893, SD = 6.54) (table 2), whereas the average height of those whose conscription had been delayed by two years was slightly lower, at 177.9 cm (N = 2279, SD = 6.54).

Secular height trend since 1878

In Switzerland a standardised national conscription procedure was introduced in 1875 and we have been able to combine all of the average height values collected during the procedure with individual data on 19-year-old conscripts for the period 1992–2009 (fig. 2). In 1878–79 the average height of 19-year-old conscripts (birth years 1859–60, N = 43 049) was 163.3 cm (distribution shown in figure 1, see also table 3). Comparing these figures with those for 2008–09 we found that the height of this age group increased by 14.9 cm over the course of this 130 year time span (fig. 1). Average height began to climb steadily in the 1890s (birth years in the 1870s), and this trend did not begin to slow down until the 1990s (birth years in the 1970s) (fig. 2). Whilst the upward trend was very slight at first (only 0.1 cm from 1878–79 to 1889), by the next decade it had increased to 2.3 cm from 1889 to 1908/10. From 1957 to 1987 the increase ranged from 1.3 cm to 2.0 cm per decade at which point it diminishes markedly, to 0.8 cm between 1987 and 1997 and then to a mere 0.6 cm between 1997 and 2007. (The 95% confidence intervals of all given increases per decade in cm are between ± 0.08 and ± 0.1 cm.)

Thanks to the availability of three published documents dating from the late 19th and early 20th centuries in which the medical examination measurements have been pre-

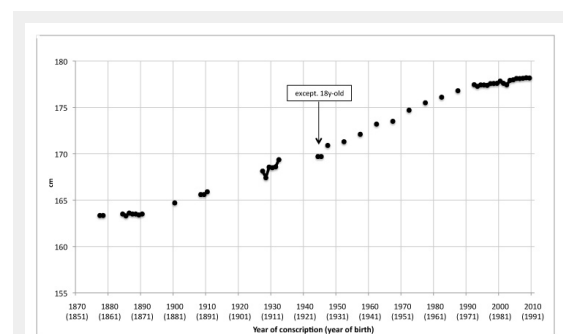


Figure 2

Evolution of the average height (cm) of 19-year-old Swiss conscripts from 1878–79 to 2009 (1992–2009: individual data, before 1992: published averages).

served, we are able to define a shift in the x axis of the height distribution over the course of 130 years (fig. 1). In 1878–79, a paltry 5.48% of the 19-year-old conscripts were 175 cm tall or taller and only a minuscule 0.89% were at least 180 cm tall. In 2008–09, a full 71.13% of the conscripts were 175 cm tall or taller, and 41.69% were at least 180 cm tall. In summary, the upward trend at the two ends of the 130 year time period, from 1878–79 to 1891 and from 1993–94 to 2008–09, was modest, most of the increase being concentrated in the middle hundred years.

Discussion

The secular height trend of 19-year-olds reflects the fact that the velocity of an individual's growth has evolved. During the 19th century, a 19-year-old had yet to achieve his maximal height [57]. Our modern data indicate that 20- and 21-year-olds were no taller, on average, than the average 19-year-old measured in 2009. However, since the secular height trend is reflected in the average heights (female

as well as male) derived from Swiss passport applications and prison records since the late 19th century, it is evident that a faster individual growth tempo alone does not entirely explain the secular height trend [8]. What is more, the average height of conscripts who were 18 years of age (since 2004), when they were measured, is slightly greater than that of the conscripts who were one year older. The fact that (on account of the 2004 change in the conscription regulations permitting conscription at the age of 18), these 18-year-olds had volunteered for early conscription goes far to explain this discrepancy, since their readiness to serve suggests that their physical development was more advanced than that of the conscripts who opted otherwise. However, the secular height trend remains to be satisfactorily explained. Changes at the genetic level are of minor consequence [58]. Possible primary causes include a complex cluster of improvements in the standard of living, chiefly nutritional [for the milk hypothesis see 59], but also in regard to hygiene and the disease environment, not to mention a decrease in the physical workload, particu-

Table 1: Average height, age, and height percentiles of individual Swiss conscript data 1992–2009.

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
19-year-old																		
Mean age (year/month)	19/04	19/04	19/04	19/04	19/04	19/04	19/04	19/04	19/04	19/04	19/04	19/05	19/06	19/06	19/06	19/06	19/06	19/06
N	7125	12120	11377	12578	13033	13513	13686	14297	14549	13953	13470	10519	12375	15168	16486	16483	15885	12447
Average (cm)	177.5	177.3	177.4	177.4	177.4	177.6	177.6	177.6	177.8	177.6	177.4	177.9	177.9	178.1	178.1	178.2	178.2	178.2
SD	6.59	6.46	6.46	6.50	6.56	6.53	6.48	6.47	6.55	6.60	6.61	6.45	6.49	6.39	6.48	6.47	6.48	6.52
5th Percentile	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	168.0	167.0	168.0	168.0	168.0	168.0	168.0
10th Percentile	169.0	169.0	169.0	169.0	169.0	169.0	169.0	170.0	170.0	169.0	169.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0
25th Percentile	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
50th Percentile	177.0	177.0	177.0	177.0	177.0	177.0	178.0	178.0	178.0	177.0	177.0	178.0	178.0	178.0	178.0	178.0	178.0	178.0
75th Percentile	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	183.0	182.0
90th Percentile	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	187.0	187.0
95th Percentile	189.0	188.0	188.0	188.0	188.0	188.0	188.0	188.0	189.0	189.0	188.0	189.0	189.0	189.0	189.0	189.0	189.0	189.0
18-year-old																		
Mean age (year/month)	18/09	18/09	18/09	18/09	18/09	18/09	18/09	18/09	18/09	18/08	18/08	18/09	18/09	18/09	18/09	18/08	18/08	18/08
N	5042	13172	12904	14351	14651	16649	16779	17694	18098	18765	19195	9869	6121	6664	7123	8208	7664	6309
Average (cm)	177.3	177.2	177.2	177.5	177.3	177.4	177.3	177.3	177.7	177.4	177.3	177.8	178.1	178.2	178.3	178.3	178.4	178.3
SD	6.44	6.52	6.51	6.51	6.53	6.55	6.53	6.54	6.48	6.48	6.55	6.50	6.47	6.40	6.48	6.51	6.45	6.39
5th Percentile	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	167.0	168.0	168.0	168.0	168.0	168.0
10th Percentile	169.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0	170.0	169.0	169.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0
25th Percentile	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	173.0	174.0	174.0	174.0	174.0	174.0	174.0
50th Percentile	177.0	177.0	177.0	177.0	177.0	177.0	177.0	177.0	178.0	177.0	177.0	178.0	178.0	178.0	178.0	178.0	178.0	178.0
75th Percentile	182.0	182.0	181.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	182.0	183.0	183.0	183.0	183.0
90th Percentile	186.0	186.0	185.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	186.0	187.0	187.0	187.0	187.0
95th Percentile	188.0	188.0	188.0	188.0	188.0	188.0	188.0	188.0	188.0	188.0	188.0	189.0	188.7	189.0	189.0	189.0	189.0	189.0
18-20-y-old																		
N	12167	25292	24281	26929	27684	30162	30465	31991	32647	32718	32665	20388	18496	21832	23609	24691	23549	18756
Average (cm)	177.4	177.2	177.3	177.5	177.4	177.5	177.4	177.4	177.7	177.5	177.4	177.9	178.0	178.1	178.2	178.2	178.3	178.2

Table 2: Average heights for five one-year age groups (18–22 years) in the conscription year 2009 (N = 29707).

Age	Average (cm)	N	SD
18-19	178.3	6309	6.39
19-20	178.2	12447	6.52
20-21	178.2	6893	6.54
21-22	177.9	2279	6.54
18-22	178.2	29707	6.52

larly during childhood [3, 5, 6, 34, 60]. Other contributing factors are found in positive assortative pair mating and epigenetics [9, 61]. Average height usually increases in tandem with improvements in other economic and biological measures of the standard of living (GDP per capita, real wages, life expectancy, infant mortality). This cluster of factors, however, does help to explain the secular height trend in Switzerland [8, 49].

The secular height trend in Switzerland soared during the two decades between the First and Second World Wars, largely due to the prescription of iodine as an incipient goitre prophylaxis, Vitamin D as a rickets prophylaxis, and major improvements to the social welfare system, including intensified meal and holiday programmes for needy children [8]. Even when international comparison of average height levels is hindered by differences among military conscription systems, it is safe to say that average height in Switzerland, in the second half of the 19th century at the low level of southern Europe, caught up with that of France and Belgium on the eve of the First World War, which was roughly equivalent to average height in Central European countries today [12, 34, 36]. This fits surprisingly well with findings on material standard of living, when real wages were substantially lower in Switzerland than in other European countries, including Southern Europe, until the 1870s, then caught up during the globalisation process and conversed with the level of France or Belgium at the eve of First World War [62].

Another phenomenon that remains to be satisfactorily explained is the slowdown since the 1990s in Switzerland's height-increase trend (which has its parallel in Northern as well as elsewhere in Central Europe), together with an increasing delay in the age of menarche [9]. At this stage,

it is not clear whether this trend is short term or whether, due to the stable environment of Central and Northern European countries, the genetic endpoint of the population has been reached, at a mean level of 178–180 cm [9, 34]. The fact that US heights reached a plateau toward the middle of the 20th century, despite an increase in the average income level, is explained by the inadequacy of the social safety net (including the health care system), the poor quality of nutrition and social inequality [38, 63]. It is also correlated with the obesity epidemic [37, 64–66]. Whether – and if so, then to what degree – similar phenomena could play a role in the height trend slowdown and the obesity epidemic, 30 to 40 years later, in Switzerland [48] is an issue worth examining. Another potential explanation is the influence of structural change, such as the “1950s Syndrome”, the end of the so-called golden age between the late 1950s and the “oil price shock” of 1973 [67]. A Vitamin D deficiency causing height differences [68], could also account for the fact that the upward secular height trend in northern and western regions of Europe has reached a plateau [69–71].

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Table 3: Published average heights of Swiss conscripts 1878/79–1987.

Year of conscription	Av. height (cm)
1878/79	163.3
1884	163.5
1885	163.3
1886	163.6
1887	163.8
1888	163.5
1889	163.4
1890	163.5
1900	164.7
1908	165.2
1909	165.7
1927	168.1
1928	167.4
1929	168.6
1930	168.5
1931	168.6
1932	169.4
1944	169.7
1952	171.3
1957	172.1
1962	173.2
1967	173.5
1972	174.7
1977	175.5
1982	176.1
1987	176.8

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